

Comparison of prognostic models for severe burn patients in an Indonesian tertiary hospital: retrospective study



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ABSTRACT

Background: Despite the high burn-related mortality rate, few studies investigate the discriminating power of various mortality prognostic models for burn patients in the Indonesian setting. Thus, the objective of our study is to describe and compare the discriminating power of several prognostic models for burn patients, including the Prognostic Burn Index (PBI), Belgian Outcome of Burn In-jury (BOBI), Revised Baux Score (rBaux), and Abbreviated Burn Severity Index (ABSI).

Patients and methods: We conducted a retrospective study using medical records data with analysis including patients with severe burn (>20% Total Body Surface Area (TBSA), >10% for children and elderly), excluding those with known chronic conditions. Statistical analyses were performed on IBM SPSS 23.0 and included ROC curve and diagnostic values calculation, including sensitivity, specificity, positive, and negative predictive values with 95%CI.

Results: Final analysis included 117 subjects with a 38.9% mortality rate. All prognostic models were statistically significant discriminating power with Area Under the Curve (AUC) values of 0.817, 0.849, 0.929, and 0.859, respectively. Comparing diagnostic values identified rBaux to have the strongest discriminating power with the highest specificity, PPV, and NPV. PBI score was identified with the highest sensitivity score.

Conclusion: Discrepancy of results between our study and another Indonesian study with a similar design pointed to the need for a multi-centered study with a larger sample size to improve generalizability and statistical power of analysis.

Keywords: burn injury; prognostic models; PBI; rBaux; BOBI; ABSI; Indonesia.

Cite This Article: Oenarta, E.G., Hamid, A.R.R.H., Sanjaya, I.G.P.H., Adnyana, I.M.S., Mahadewa, T.G.B., Harimawan, A.I.W. 2022. Comparison of prognostic models for severe burn patients in an Indonesian tertiary hospital: retrospective study. *Bali Medical Journal* 11(1): 211-215. DOI: 10.15562/bmj.v11i1.3378

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Received: 2022-01-20

Accepted: 2022-03-30

Published: 2022-04-11

INTRODUCTION

A prognostic model for burn patients has been developed to help clinicians determine new patients' mortality risk. These prognostic models often consider the patient's demographic characteristics, the total body surface area (TBSA) of the burn, inhalation injury, and other factors. Some of the most frequently used prognostic models in the Indonesian clinical setting included the Revised Baux Score (rBaux), Belgian Outcome of Burn Injury (BOBI), and Abbreviated Burn Severity Index (ABSI).¹ Another prognostic model has also been developed in Japan, known as the Prognostic Burn Index (PBI).²

These prognostic models have been developed and validated in their respective populations.³⁻⁶ However, there are remaining knowledge gaps regarding

using these models in clinical settings, especially in Indonesia. One such gap is the lack of data showing the accuracy of these predictive models when used in the Indonesian clinical setting. Another is the lack of data that compares the accuracy of these models. These gaps are relevant given what we know regarding the disparity of mortality risk between countries and even between hospitals within the same country.^{7,8} To the authors' knowledge, only one such study in Indonesia reported data from only one tertiary healthcare facility.¹

This knowledge gap is highly relevant to clinical practice as it led to the variability of prognostic models used in clinical settings. Recent development has identified several effective treatments to prevent mortality for burn victims.⁹ However, misidentification of mortality risk may lead to the late application of

said treatments in low-resource settings. Identification of mortality risk would help inform clinicians to make the best medical advice for the patient and allocate resources as necessary.¹⁰ Thus, identifying the most appropriate mortality prognostic models in each specific clinical setting would help fill the gap between treatment and mortality rate, especially in low-resource settings such as Indonesia.

We aim to fill in the gaps of knowledge on the accuracy of the burn prognostic model in the Indonesian clinical setting. Thus, we conduct this study with the primary objective to describe the accuracy of the four most frequently used prognostic models for burn patients in an Indonesian tertiary healthcare facility. Another objective of the study is to compare the prognostic modes described therein to identify the most accurate model to use in

clinical settings. This information would then help answer the gap between clinical treatment and mortality rate by identifying the most appropriate prognostic model in the specific clinical setting.

MATERIAL AND METHODS

This study employed a retrospective design with data collected from medical records in a tertiary hospital in Denpasar, Bali, Indonesia. We collected data from severe burn patients admitted to the hospital from January 2019 to December 2020. Severe burn injury was defined as partial and full-thickness burn injury with TBSA of > 10% for children (aged < 18 years old) and elderly (aged > 65 years old) or > 20% for adults.¹¹ We exclude patients with recorded comorbidities, such as diabetes mellitus, hypertension, cardiac disorders, lung disorders, liver disorders, kidney failures, and other chronic conditions. We also exclude patients with incomplete medical records or insufficient data for variables of interest.

The dependent variable for analysis was the outcome of treatment which was dichotomized into in-hospital mortality and survival at discharge. Prognostic models included for analysis included PBI, BOBI, rBaux, and ABSI scoring systems. All calculation was conducted based on data available on the medical

record and conducted by a data collection officer familiar with using these scores in academic and clinical settings. Other than that, we also collected data on the patient's clinical characteristics, including age, sex, degree of burn injuries sustained, and TBSA affected by burn injuries. Based on medical record information, PBI was calculated based on the description by Kaita et al. and Nakae & Wada.^{2,3} Similarly, BOBI and ABSI scores were calculated based on the description by Sheppard et al.¹² Meanwhile, rBaux score was calculated based on the description by Osler et al.⁶

Descriptive analysis was conducted, including normality tests (Kolmogorov-Smirnov test), a bivariate Chi-squared test for cross-tabulation, and a non-parametric Mann-Whitney test to identify differences in characteristics between mortality cases and survivors. The receiver operating characteristic (ROC) curve conducted the primary analysis to identify discriminating power based on the area under curve (AUC) value and identify the optimal cut-off point for mortality prediction for each score. The optimal cut-off point was then identified using the Youden Index calculation. Subjects were then dichotomized based on the optimal cut-off points identified for each prognostic model. Afterward, we calculated the sensitivity, specificity, positive predictive

value (PPV), and negative predictive value (NPV). We also calculated 95% confidence interval (95% CI) for each value according to the formula by Ying et al.¹³ Statistically significant difference in discriminating power was determined by overlapping 95% confidence interval between different prognostic models. All statistical analyses were conducted using IBM SPSS 23.0.

RESULTS

Data collection yielded 117 patients that fulfilled the analysis's inclusion and exclusion criteria (Table 1). It included 77 males (68.8%) and 40 females (34.2%). The overall median age was 31 years old, although it has wide age variation with an interquartile range (IQR) ranging from 7 years old to 51 years old. The youngest subject was only one year old, while the oldest was 78 years. Based on clinical presentation, most subjects suffered a partial-thickness burn in the worst burnt area of their body (16.2% as IIA and 61.5% as IIB). Only 22.2% suffered any full-thickness burn injury. However, as much as 30.8% of subjects suffered inhalation trauma. Meanwhile, the overall median TBSA was 28.5%, with IQR from 17.0% to 42.5%. The low median TBSA corresponds with a wide range of age distribution where the subject population includes a significant number of children for whom

Table 1. Basic characteristics of subjects.

Variables	Total (n=117)	Outcome		
		Survive (n = 75)	Mortality (n = 42)	p
Age (years), median (IQR)	31.0 (7.0 – 51.0)	20.0 (4.0 – 49.0)	42 (25 – 59)	0.001*
Sex, n (%)				0.581 ^b
Male	77 (68.8)	48 (64.0)	29 (69.0)	
Female	40 (34.2)	27 (36.0)	13 (31.0)	
Degree of burn, n (%)				< 0.001*
IIA	19 (16.2)	19 (100.0)	0 (0.0)	
IIB	72 (61.5)	46 (63.9)	26 (36.1)	
III	26 (22.2)	10 (38.5)	16 (61.5)	
Inhalation trauma, n (%)				< 0.001*
No	81 (69.2)	65 (80.2)	16 (19.8)	
Yes	36 (30.8)	10 (27.8)	26 (72.2)	
TBSA (%), median (IQR)	28.5 (17.0 – 42.5)	23.0 (14.5 – 30.75)	44.5 (31.0 – 71.0)	< 0.001*
PBI score, median (IQR)	54.0 (20.25 – 69.0)	36.0 (14.0 – 58.75)	69.75 (57.0 – 84.0)	< 0.001*
BOBI score, median (IQR)	1.0 (1.0 – 5.0)	1.0 (0.5 – 2.0)	5.0 (2.0 – 7.0)	< 0.001*
rBaux score, median (IQR)	48.0 (13.5 – 99.5)	20.0 (1.5 – 54.25)	106.75 (79.0 – 131.5)	< 0.001*
ABSI score, median (IQR)	6.0 (3.0 – 9.0)	4.0 (2.3 – 7.0)	9.0 (8.0 – 11.0)	< 0.001*

Notes:

Abbreviations: IQR, interquartile range.

Legend: *p < 0.05

the cut-off point for severe burn was set at > 10%.

Only 75 would be alive at discharge from the hospital (64.1%), while 42 (35.9%) recorded in-hospital mortality. Chi-square tests for categorical variables and the Man-Whitney test for continuous variables found significant demographic and clinical differences between survivors and mortality cases (Table 1). Differences were found in age, burn severity, and TBSA characteristics, which were higher in the mortality group. Similarly, the distribution of predictive model scores differed between the two groups, where the median score was higher in the mortality group.

ROC analysis found all prognostic models to have statistically significant discriminating power (Table 2). Based on AUC values shown in Table 2 and Figure 1, PBI, BOBI, and ABSI were categorized to have moderate discriminating power (AUC 0.7 – 0.9). Only rBaux was categorized with strong discriminating power (AUC >

0.9). There was no statistically significant difference of discriminating power between analyzed prognostic models.

Youden Index analysis identified the optimal cut-off points for mortality prediction were 50.625 for PBI, 2.5 for BOBI, 74.75 for rBaux, and 7.5 for ABSI. Analysis of prognostic values based on the cut-off points showed that while PBI was found with the highest sensitivity value, rBaux was identified with the highest specificity, PPV, and NPV values (Table 3). Further, the specificity value of rBaux is significantly higher than that of PBI (95% CI of 80.64% - 95.35% for rBaux and 54.56% - 76.10% for PBI). Otherwise, there was no statistically significant difference between the prognostic values of different models included in the analysis.

DISCUSSION

Our study found a mortality rate of 38.9% among severe burn patients. This result is much higher compared to several previous

studies.^{1,14} It should be noted that neither of these studies limited inclusion to severe burn injury. It may affect the survival probability of their subjects.

More comparable subject characteristics are available from an Australian-New Zealand study which limited the analysis to severe burn patients.¹⁵ However, our reported mortality rate was more than twice what was reported there. This is in line with previous reports that showed a higher burn-related mortality rate from Southeast Asian countries, including Indonesia, than in high-income Western countries.⁸

Looking specifically at prognostic models included in the analysis, we see that the rBaux model has the strongest discriminating power compared to other models. This can be seen from comparing AUC, specificity, PPV, and NPV figures where the rBaux model was found to have the highest value. In contrast, the PBI score has the highest sensitivity score. High sensitivity would be useful at the onset of treatment to identify which patient is at the highest risk of mortality, thus requiring more aggressive treatment. Meanwhile, high specificity and PPV would be useful to decide on the termination of life-support at the end of treatment. In the end, however, a clinician should always make a clinical judgment based on a holistic evaluation of the patient and not basing their decisions on a single score system.¹⁶

Regarding the discriminating power of rBaux, there have been several

Table 2. Area under curve for mortality prediction.

Prognostic Model	AUC	95% CI	p
PBI	0,817	0,738 – 0,896	< 0,001*
BOBI	0,849	0,773 – 0,925	< 0,001*
rBaux	0,929	0,884 – 0,975	< 0,001*
ABSI	0,859	0,786 – 0,925	< 0,001*

Notes:

Abbreviations: PBI, Prognostic Burn Index; BOBI, Belgian Outcome of Burn Injury; rBaux, Revised Baux Score; ABSI, Abbreviated Burn Severity Index; AUC, area under curve; 95% CI, 95% confidence interval.

Legend: *p < 0.05

Table 3. Prognostic values for each prognostic model included in analysis.

Prognostic Model	Outcome		Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
	Mortality (n = 42)	Survive (n = 75)				
PBI						
≥ 50.625 (n = 62)	36	49	85.71%	65.33%	58.07%	89.09%
< 50.625 (n = 55)	6	26	(75.13% - 96.30%)	(54.56% - 76.10%)	(45.78% - 70.35%)	(80.85% - 97.33%)
BOBI						
≥ 2.5 (n = 43)	30	13	71.43%	82.67%	69.77%	83.78%
< 2.5 (n = 74)	12	62	(57.77% - 85.09%)	(74.10% - 91.23%)	(56.04% - 83.50%)	(75.39% - 92.18%)
rBaux						
≥ 74.75 (n = 44)	35	9	83.33%	88.00%	79.54%	90.41%
< 74.75 (n = 73)	7	66	(72.06% - 94.60%)	(80.64% - 95.35%)	(67.63% - 91.46%)	(83.66% - 97.17%)
ABSI						
≥ 7.5 (n = 46)	32	14	76.19%	81.33%	69.57%	85.92%
< 7.5 (n = 71)	10	61	(63.31% - 89.07%)	(72.52% - 90.15%)	(56.27% - 82.86%)	(77.82% - 94.01%)

Notes:

Abbreviations: PBI, Prognostic Burn Index; BOBI, Belgian Outcome of Burn Injury; rBaux, Revised Baux Score; ABSI, Abbreviated Burn Severity Index; AUC, area under curve; 95% CI, 95% confidence interval.

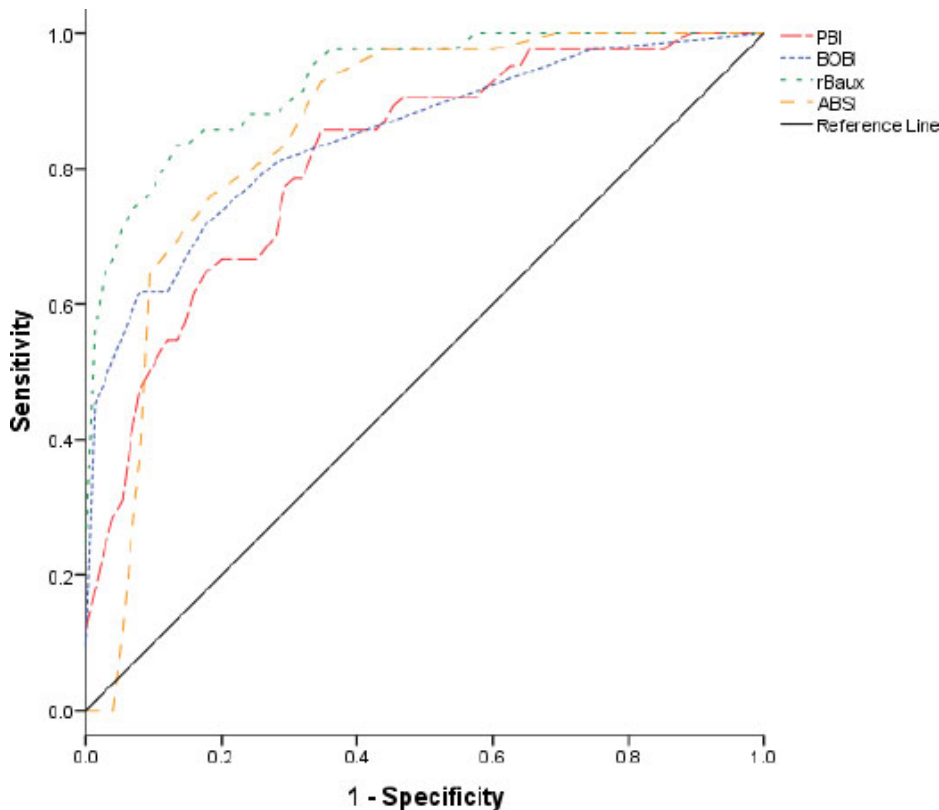


Figure 1. ROC curve for PBI, BOBI, rBaux, and ABSI prognostic models.

comparison studies with similar results. Two Japanese studies comparing PBI, BOBI, rBaux, and ABSI models, among others, also found rBaux model to have the strongest discriminating power based on a comparison of AUC values.^{3,17} Conversely, the only other similar study from Indonesia found a different result. Comparing Ryan, rBaux, BOBI, and ABSI, Herlianita et al. found the ABSI model to have the strongest discriminating power.¹ Nevertheless, all these studies have similarly found that these differences are not statistically significant despite differences in discriminating power.

Other than discriminating power, another important criterion for selecting a prognostic model in clinical use is acceptability and ease of use by clinicians themselves. Other than finding ABSI to have the strongest discriminating power, Herlianita et al. argued that it is also easy to use by clinicians with a clear and concise score assignment based on definitive criteria.¹ While some prognostic models have complicated formulas, especially for rBaux, some have been simplified for ease of use. The 12 rBaux

models have been especially simplified by nomogram development, which removes the necessity to calculate complicated formulas in clinical practice settings. With a nomogram available, a clinician can estimate the mortality probability based on rBaux model using nothing but a ruler.¹⁸

Another interesting finding from our data is the different cut-off points identified in this study compared to previous validation of the prognostic models. The validation studies of prognostic models included in our study did not provide a clear cut-off point. However, it provides interpretation tables that match certain score values with their mortality probability counterpart. This is true for PBI, BOBI, and ABSI models.^{12,19} Interestingly, we found that the optimal cut-off point based on our data corresponds to a mortality probability of around 5-10% based on these previous validation studies.^{12,19}

Considering that most validation studies were conducted in high-income Western countries, this discrepancy can be explained by the established difference

in burn-injury-related mortality rate.⁸ However, it further showed how urgent local validation of these prognostic models for clinical use in Southeast Asian countries, including Indonesia. To the authors' knowledge, this article is one of few such studies reporting the discriminating power of prognostic models for severe burn patients conducted in Indonesia with Indonesian subjects.

Other than that, despite consistent evidence of higher burn-related mortality rates in Southeast Asian countries, few studies investigate the underlying cause of this difference. One potential cause is the different quality of care provided. This is supported by a much lower mortality rate reported in Singaporean studies,^{20,21} a country known for its high-quality healthcare, compared to regional figures. The failure to put patients through advanced burn treatment caused by misidentifying mortality risk and limited resources may lead to a difference in the quality of care and mortality rate. Identifying the underlying cause for high mortality rate in low-resource Southeast Asian countries should be a focus of investigation for researchers working on burn-related epidemiology in the region.

However, our study is not without its limitations. We only included a modestly sized sample size collected from a single tertiary hospital in Indonesia, limiting our data's generalizability. The discrepancy of results between our study and another similar Indonesian study¹ further showed the urgency of a large, nationwide study to validate the different prognostic models for burn patients in Indonesian setting. A multi-centered study with larger sample size would improve generalizability and strengthen the statistical power of analysis.

CONCLUSION

Our study identified high mortality rate among severe burn patients in an Indonesian tertiary hospital. Analysis of four prognostic models, including PBI, BOBI, rBaux, and ABSI, found all of them have statistically significant discriminating power. A comparison of prognostic values identified rBaux as the one with the strongest discriminating power with the highest AUC, specificity, PPV, and NPV values, making it more suitable for

end-of-life decisions. Meanwhile, PBI was found with the highest sensitivity, making it useful to identify at-risk patients at admission. However, it should be emphasized that a single score is not adequate to predict a patient's prognosis perfectly. Clinicians should always make a clinical judgment based on a holistic evaluation of the patient.

ACKNOWLEDGMENTS

We want to convey our gratitude to all healthcare personnel caring for burn patients in our center. Without their dedication to caring for the patients and recording their progress, this study would not have been possible.

CONFLICT OF INTEREST

None declared.

ETHICAL CONSIDERATION

The research protocol for this study has been reviewed by the joint Ethical Committee of Sanglah General Hospital/ Faculty of Medicine, Udayana University. It has since been approved with approval letter no. 2892/UN14.2.2.VII.14/LT/2021.

AUTHOR'S CONTRIBUTION

Conceptualization: EGO & TGBM. Methods: EGO, ARRHH, IGPHS, IMSA, & TGBM. Data curation: EGO & AIWH. Formal analysis: EGO & TGBM. Writing – original draft: EGO. Writing – review & revisions: TGBM, ARRHH, IGPHS, IMSA, & AAIWH.

FUNDING

None.

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